THE OVERTURNS IN THE DENVER BASINS.

GEOLOGICAL field work in the foothill region of the Denver Basin has possibly been hampered to some extent by the assumption that the overturn of certain formations — and the locally increased dip of the higher strata in other cases — were caused by the tangential, or nearly horizontal, pressure which is commonly supposed to have produced the mountain range. It is very possible that the direct effect of gravitation has not received sufficient consideration. Without in the slightest degree discrediting the lateral-compression theory of mountain uplift, of which there is

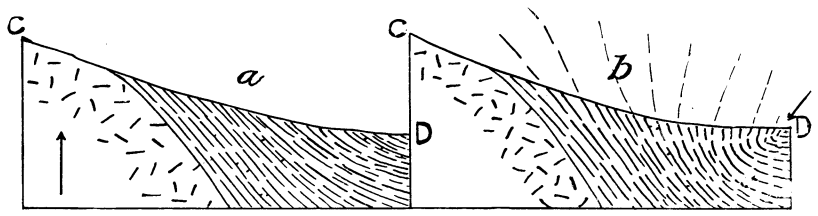

FIG. 1 (after figure in Monograph XXVII, U. S. Geol. Survey, p. 47). — *A* shows effect of vertical upward pressure, with dip of strata nearest the point of uplift greater than at a more distant point. *B* shows effect of tangential pressure.

other evidence along the foothills, it is worthy of notice that the overturning of strata flanking the foothills, may, at least in many places, and in every instance with which the writer is familiar, be, with good reason, ascribed to a very different cause.

In Monograph XXVII, United States Geological Survey, *Geology of the Denver Basin*, the fact is pointed out that the strata at some distance from the Archæan are generally tilted to a much higher angle than those lying nearer the granitic axis of the range, and this is deemed an indication of tangential compression. Two diagrams are given to show the different effects of vertical upward and oblique downward pressure, which are here reproduced, Fig. 1.

Acceptance of that idea without further investigation led the writer and others at first to overlook certain phenomena, until

the discovery of what appear to be Benton shales on the south side of Boulder Creek, disappearing under the apparently overturned Jura-Trias at the base of Flagstaff Mountain (the axis of the Boulder Arch, described in the monograph before mentioned), compelled a re-examination of the subject. In this vicinity the most pronounced overturn is in the Niobrara basal limestone, which is very hard and sufficiently resistant to form a ridge making element. It is normally overlaid by several thousand feet of easily eroded Upper Niobrara and Pierre shales, and underlaid by Benton shales. When these formations are erected to a position approaching the vertical, the rapid cutting away of Upper Niobrara and Pierre shales must inevitably leave the Niobrara limestone partly unsupported on the east side, to bear the burden of the lateral pressure of the mountain column upon its base. Flagstaff Mountain rises abruptly about 1,000 feet above the upturned edge of the limestone. Other foothills are still higher, others still are lower and less abrupt, while beyond the foothills the main Rocky Mountain range towers to a height of from 10,000 to over 14,000 feet above the level of the sea.

There are reasons for supposing that at Flagstaff, as the unsupported limestone gave way and overturned, a break in the underlying Dakota (here very thin) and in Jura-Trias permitted the latter to swing outward at the base and inward and downward at the apex, thus executing a partial revolution on an axis. In the meantime, the yielding Benton shales crowded down into the opening thus made, and the broken edges of the Triassic, swinging outward, passed out over the Dakota, Benton, and Lower Niobrara in such a position as now to rest upon the overturned Niobrara shales, giving the impression at first glance that the Dakota, Benton, and Lower Niobrara had never been deposited, and that the Triassic had participated with the Upper Niobrara in the overturn. The following diagram, drawn by Mr. H. F. Watts, of Boulder, Colo., who was associated with the writer in this work, will be an effectual aid to an understanding of what seems to have taken place.

After solving the problem at this point, it was easy to recognize

the same phenomenon (which in local field parlance has been designated a "slump") at various points north and south for some distance. It frequently results in the production of a bench similar to the one on Flagstaff, locally known as Huggin's Park, but does not usually result in covering intervening formations on so extensive a scale. Whether like conditions exist at

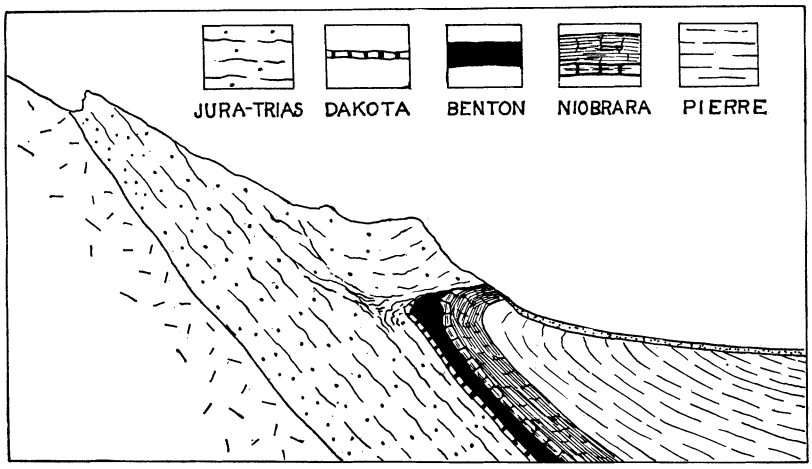

FIG. 2.— Cross-section of east slope of Flagstaff Mountain.

all places in the Denver Basin where overturns occur, the writer is unable to say, not being familiar with the foothill region south of the Boulder county line; but the matter is worthy of further investigation before assuming that such overturns have any bearing upon the theories of mountain structure. The same process that caused the overturns in these cases, has presumably caused the greater dip of the later formations in cases where they have not been overturned.

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